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Physics. — *"A remarkable case of quantization."* By Prof. P. EHRENFEST and G. BREIT.

(Communicated at the meeting of January 28, 1922).

1. It is possible to indicate simple mechanical systems for which a formal application of the quantum rules gives well defined and yed apparently unreasonable stationary motions. BOHR's Principle of Correspondence [1]) offers an essentially new viewpoint for the treatment of these cases and will probably contribute to their complete solution. It will suffice to discuss a special case which is so chosen as to minimize the mathematical analysis. [2])

2. A rigid electric dipole having a moment of inertia I is free to rotate in the X, Y plane about its own midpoint.

Let us suppose that by means of a suitable kinematical arrangement the rotating dipole is thrown back elastically as soon as the angle φ, which the dipole makes with the axis of X, reaches the boundaries of the interval

$$-f.2\pi \leqq \varphi \leqq +f.2\pi \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (1)$$

where f is a large, in general an irrational number. Let an angular velocity ω be given to the dipole. Its angular momentum is then $p = I\omega$ and it executes a periodic motion with the *period*

$$T = 4f.\frac{2\pi}{\omega} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (2)$$

During the motion the dipole traverses the interval (1) making in a period $2f$ complete revolutions to the right followed by the same number of revolutions to the left. In the motion the *"quasi-periode"*

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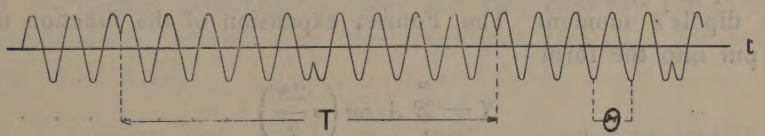
[1]) N. BOHR, Quantum theory of line-spectra I, II Kopenhagen 1918. H. KRAMERS, Intensities of spectral lines. Kopenhagen 1919.

[2]) A case which differs slightly from the one discussed in § 2, namely the case of a rigid dipole torsionally suspended by an elastic thread of small rigidity one of us submitted to EINSTEIN for consideration as early as 1912 (with reference to the problem of quantization of H_2 molecules — P. EHRENFEST. Verh. d. D. Phys. Ges. **15**, 451, 1913). It was impossible however to settle the difffculty here discussed by the means which were then available.

$$\Theta = \frac{2\pi}{\omega} \quad \ldots\ldots\ldots \quad (3)$$

becomes noticeable. This period is a $4f^{th}$ part of T and is equal to the time taken by the dipole to make a complete revolution through the angle 2π. The projection of the moment of the dipole on a line in the plane X-Y-say on the axis of X depends on the time in the manner shown on the figure (for the sake of economy the "large number" f is here taken as being approximately 2).



3. The quantum relation for our system is

$$\int p dq = nh \qquad (n = 0, 1, 2 \ldots) \quad \ldots\ldots \quad (4)$$

where the coordinate q is the angle φ, p is the corresponding momentum I ω and the integral is taken over a complete perid T. This gives in our case

$$4f \cdot 2\pi p = nh \quad \ldots\ldots\ldots \quad (5)$$

or

$$p = n\frac{h}{8f\pi} \quad \ldots\ldots\ldots \quad (6)$$

If now the restricting boundary of the interval (1) is so chosen as to make f very large, then the differences between consecutive values of p (see (6)) (and therefore also between consecutive values of the energy) are very small.

4. This result appears to be unacceptable. In fact if we pass to the limit of $f = \infty$ i.e. if the restriction of the boundaries on the dipole disappears then equation (4) gives certainly

$$p = m\frac{h}{2\pi} \quad \ldots\ldots\ldots \quad (7)$$

for now θ is the period. Here (Equ. (7)) p changes by finite steps whereas if the previous consideration be applied (Equ. (6)) the steps become infinitesimal for $f = \infty$. This is the contradiction to be discussed.

5. Bohr's principle of correspondence offers a new point of view for the treatment of this case. As before let f be a very large

number and suppose that the permissible values of p are truly given by Equ. (6). We want to know the requirements made by the principle of correspondence as to the "probability of a transition" from the state $n = n_1$ to the state $n = n_2$ (say as the result of absorption in a field of radition). The Principle of correspondence regards the probability of the transitions as analogous to the amplitudes of "corresponding" harmonics in a Fourier series expansion of the function represented graphically on the figure. This function represents the dependence on the time of the X or Y component of the dipole's moment. The Fourier expansion of the function may be put into the form

$$X = \sum_1^\infty A_s \cos\left(s\frac{2\pi}{T}\right) \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (8)$$

The harmonics "corresponding" to the transition $n_1 \rightarrow n_2$ are given by:

$$s = n_2 - n_1 \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (9)$$

From an inspection of the figure or by means of a short calculation it becomes apparent that for a large value of f the amplitudes of all the harmonics are small with the exception of those harmonics whose period is nearly equal to the "quasiperiod" θ i.e. with the exception of those for which

$$\frac{T}{s} \cong \theta \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (10)$$

or

$$s \cong 4f \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (11)$$

Therefore if f is large all the transitions have a very small probability with the exception of those for which very nearly

$$n_2 - n_1 \cong 4f \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (12)$$

and therefore (in virtue of (6))

$$p_2 - p_1 = (n_2 - n_1)\frac{h}{4f \cdot 2\pi} \cong \frac{h}{2\pi} \quad . \quad . \quad . \quad . \quad . \quad . \quad (13)$$

which is the same as the interval between consecutive values of p prescribed by (7) for infinitely large values of f.

6. If therefore we should take a collection of identical samples of our system having all the same *very large value of f*, being all at rest i.e. in the state $p = 0$ at the time $t = 0$ and if we should subject each sample independently to the action of a black body radiation — then we should find at a later time t that:

A. Out of the very dense succession of the p levels which are

permitted by (6) only those are occupied by an appreciable number of the systems which nearly coïncide with the levels of p given by (7).

B. The transitions which take place have almost without exception the magnitude $\frac{h}{2\pi}$ (and not a multiple of it) (See (13)). This is again in good agreement with the fact that for $f = \infty$ the FOURIER expansion of the x (or y) component contains only the fundamental and no higher harmonics so that for this case the Principle of Correspondence allows only the transitions (see (7)) for which $m_2 - m_1 = \pm 1$.

7. A question must now be mentioned the precise explanation of which would be of value. For the discussion of thermal equilibrium in our complex we must know the "weights" (the *a priori* probability) to be ascribed to each p level. For $f \pm \infty$ it would appear that the same weight should be given to every stop of (6) — independently of the value of f and independently of the density with which the levels follow each other. On the other hand for $f = \infty$ only the levels given by (7) are to have a weight (the same for all). A closer examination of this case will probably make it necessary to consider the fact that we are concerned here with a double limit viz. $lim\ t = \infty$ (the lapse of an infinitely long time for the establishment of thermal equilibrium) and $lim\ f = \infty$; our dissatisfaction is really based on an unconscious demand that the result should be independent of the order in which the two limits are approached.

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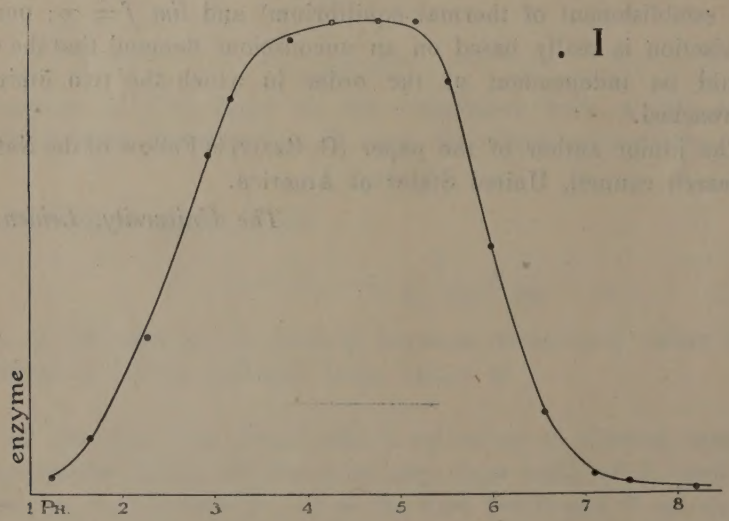
Botany. — *"The influence of hydrogen ion concentration upon the action of the amylase of Aspergillus niger"*. By G. L. FUNKE. (Communicated by Prof. F. A. F. C. WENT).

(Communicated at the meeting of January 28, 1922).

Aspergillus niger produces large quantities of amylase, part of which migrates into its nutritive surrounding. In the mean time the fungus forms acids which cause that medium to have a high hydrogen ion concentration. As this however seemed not to influence unfavourably the action of the amylase, the supposition was justified that the amylase of Aspergillus niger could not have its optimal action at the same hydrogen ion concentration as the ptyaline which works best at a nearly neutral or faintly acid reaction (4 and 5).

Therefore I made a preliminary investigation in the way as has been indicated first by SÖRENSEN (1). Buffer solutions however were made according to the methods of CLARK and LUBS (7).

Generally the same amounts of enzyme solution out of the nutritive liquid were mixed up with buffer solution and amylum



solution 0.16 %. The hydrogen ion concentration of this mixture was determined by aid of colorimetric indicators, the rate of hydrolysis of the amylum by the iodine reaction.

Results are plotted into the annexed curve (I). As can be seen there is no point of optimal action but a broad optimal zône extending from a P_H of about 3,5 till about 5,5.

Neither the concentration of the amylase, nor the composition of the nutritive liquid appeared to have influence. The same results were obtained with amylase extracted from the mycelium.

These results largely confirm the theory of MICHAËLIS who considers the enzymes as ampholytes (2 and 3). The form of the curve indeed is nearly identical to the dissociation rest curve of an amphotere electrolyte. According to his formulas

$$\varrho_a = \frac{1}{1 + \frac{K_a}{(H)}} \text{ and } \varrho_b = \frac{1}{1 + \frac{K_b}{(OH)}}$$

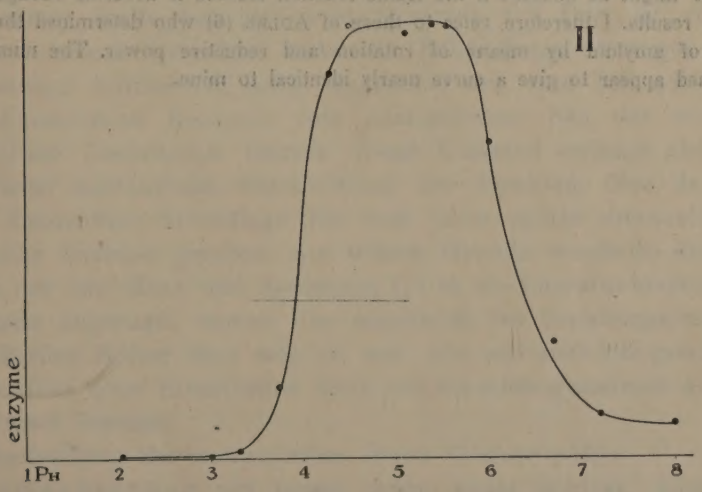
in which $\varrho = 1 - \gamma =$ dissociation rest

$\gamma =$ rate of dissociation

$K_a =$ dissociation constant of the acid

$K_b =$ dissociation constant of the base

the points on the ordinate = half of the maximum height of the curve indicate the logarithms of the dissociation constants of acid and base on the abscissa. These are to be found at about 2,26 and 6,2. So the dissociation constant of the acid would be $= 6{,}3 \times 10^{-7}$, that of the base $= 2.884 \times 10^{-12}$.



We may consider in the same way curve II which represents

the influence of the hydrogen ion concentration upon the amylase of malt[1]).

The dissociation constant of the acid appears to be the same as for the amylase of Aspergillus, that of the base on the contrary is bigger i.e. $= 5.76 \times 10^{-11}$. So as an acid the two amylases are equally strong, as a base that of the malt is the weakest.

Further investigations on other sorts of amylase will perhaps instruct us, if pointing out their differences in this way will be of any value.

Utrecht, November 1921. *Botanical Laboratory.*

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[1]) It might be doubted if the iodine reaction method is accurate enough to get exact results. I therefore refer to those of ADLER (6) who determined the hydrolysis of amylum by means of rotation and reductive power. The numbers he obtained appear to give a curve nearly identical to mine.

Palaeontology. — "*Ueber einen fossilen Baumstamm von Bolang (Java), ein Beitrag zur Kenntnis der fossilen Flora Niederländisch-Indiens*". By Dr. R. KRÄUSEL. (Communicated by Prof. J. W. MOLL.)

(Communicated at the meeting of January 28, 1922).

In der Sammlung des Mineralogisch-Geologischen Instituts der Reichsuniversität zu Groningen befindet sich ein äusserlich sehr gut erhaltenes Stück eines verkieselten Baumstammes von Bolang auf Java. Der Durchmesser des 23 cm langen Bruchstückes beträgt 19—23 cm. Ueber Fundort u.s.w. gibt folgende Notiz Auskunft: „Fossiler Baumstamm (batoe sempoer), wie solche in verschiedener Grösze, bis 2 m lang und mit einem zuweilen 60 cm erreichenden Durchmesser in Bolang auf Java gefunden werden. Sie kommen häufig auf der Oberfläche oder im Fluszbette zerstreut vor, finden sich aber auch in 1—2 m Tiefe im Boden auf dem Kamm eines Hügelzuges. (Empfangen von Herrn C. BARENDS)". Angaben über das geologische Alter der Fundschicht liegen nicht vor.

Der von Herrn Prof. Dr. BONNEMA, dem an dieser Stelle zu danken, mir eine angenehme Pflicht ist, ausgehenden Anregung zur Untersuchung des Holzes leistete ich um so lieber Folge, als es wünschenswertes Vergleichsmaterial für eine gleichzeitig durchgeführte Bearbeitung fossiler Hölzer aus Sumatra bot, über die an anderer Stelle berichtet wird (KRÄUSEL 1). Dort ist auch zu zeigen versucht worden, dasz die Behandlung derartiger Reste keineswegs nutzlos ist, selbst angesichts der zum Teil noch recht unvollkommenen Kenntnis vom anatomischen Bau der rezenten, tropischen Laubbäume. Gerade dieser Umstand verlangt aber eine möglichst ausführliche Beschreibung der Fossilien. Nur dann ist eine brauchbare Grundlage für eine etwa später vorzunehmende kritische Revision gegeben. Aus diesem Grunde wurde die Beschreibung der von MOLL und JANSSONIUS (1) in die Literatur eingeführten Methode angepaszt, soweit dies angesichts des Erhaltungszustandes der fossilen Hölzer eben möglich war. Das soll auch hier geschehen; hinsichtlich aller Einzelheiten kann auf die schon genannten Arbeiten verwiesen werden.

Beschreibung des anatomischen Baues (Topographie):

Zuwachszonen mit freiem Auge kaum sichtbar, unter dem Miskroskop an einer deutlichen Anhäufung und damit verbundenen Gröszenabnahme der Gefäsze kenntlich. Die tangentialen Schichten, die

auf dem Querschnitt für das blosse Auge Zonengrenzen ähnlich sind, enthalten zahlreiche, stets von reichlichem Holzparenchym umgebene Harzgänge und auch Gefäsze, aber fast kein Libriform. Diese Schichten nicht überall gleich deutlich, stets eine Reihe Harzgänge enthaltend, von denen 2 benachbarte zuweilen verschmelzen (auf 18 mm radialer Erstreckung kommen 5 Harzgangreihen, die sich über einen groszen Teil des Querschnitts verfolgen lassen). (Textfig. 1, Tafel, Fig. 1, 2). Gefäsze ± gleichmäszig verteilt, zu 8—16 auf dem mm², in der Regel vereinzelt liegend, seltener in Gruppen, dann oft zu zweien. Sehr oft an beiden oder wenigstens an einer Seite an Markstrahlen grenzend, sonst meist von Holzparenchym oder Fasertracheiden umgeben. Diese sehr spärlich, nur an Gefäsze grenzend. Libriformfasern die Grundmasse des Holzes bildend, ± undeutlich in radialen Reihen angeordnet.

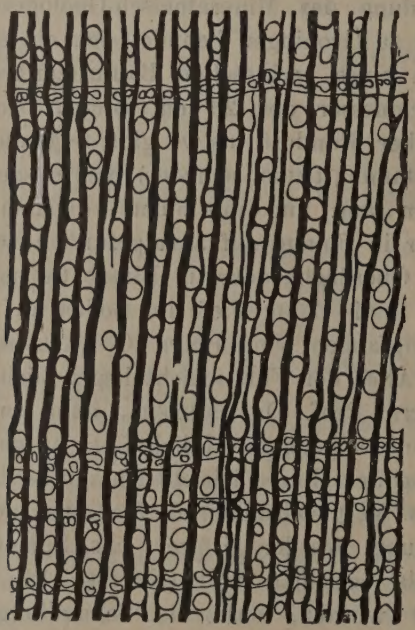


Fig. 1. Querschnitt.

Einfaches Holzparenchym die Gefäsze und Harzgänge umgebend, tangentiale Bänder bildend, einige zerstreute Fasern anscheinend auch im Libriform eingesprengt; die die Harzgänge umgebenden Zellen oft in die Breite gezogen, kaum in den Harzgang hineinragend (dünnwandiger als die anderen). Harzgänge nur in den tangentialen Bändern zahlreich, ausserhalb derselben nur vereinzelt. Markstrahlen seitlich von einander getrennt durch 1—10 Libriformfaserreihen, 1—6-,

am häufigsten 3—5-schichtig, 3—30 Zellen hoch, die breiteren nicht immer aus 3 Stockwerken zusammengesetzt, das obere und untere dann meist eine, seltener bis 4 Zellen hoch, die wie die der einfachen Markstrahlen aufrecht oder aufrechten ähnlich sind. Die breiteren Stockwerke oft von tangential häufig sehr breiten Hüllzellen umgeben. Nicht selten stehen mehrere Markstrahlen, nur durch ein oder zwei Fasern von einander getrennt, übereinander, verschmelzen auch gelegentlich ganz (Tafel, Fig. 3; Textfig. 2). Ihre Zellen enthalten oft Kristalle.

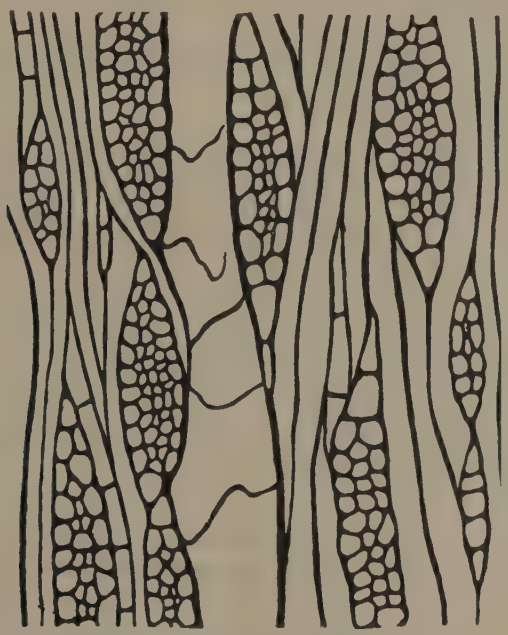


Fig. 2. Tangentialschnitt.

Beschreibung der Elemente:

Gefässe: Weite radial 65—275 μ, tangential 70—210 μ, elliptische, auch Kreiszylinder, Querwände ± horizontal (selten sichtbar), Perforation ± unkenntlich (lochförmig?) mit zahlreichen Hoftüpfeln, wo sie aneinander oder an Fasertracheiden grenzen, Tüpfel polygonalrundlich oder elliptisch; die Pori oft elliptisch, schief bis vertikal gestellt; mit einseitigen Hoftüpfeln und einfachen Tüpfeln, wenn an Holzparenchym und Markstrahlen grenzend, häufig mit dünnwandigen Thyllen erfüllt.

Fasertracheiden: Nur in der Umgebung der Gefässe vorhanden, Tüpfelung wie bei den Gefässen.

Libriformfasern: Weite radial 8—16 μ, tangential 10—16 μ,

polygonal mit oft abgerundeten Kanten, oft auch vierseitig. Tüpfel spaltenförmig, seltener auch rundlich. Interzellularräume wurden nicht beobachtet.

Holzparenchymzellen: Weite radial 10—35 μ, tangential 10—30 μ, Länge 40—200 μ, 4—8-seitige Prismen mit abgerundeten Kanten und vertikaler Achse, die Zellen um die Gefäsze und namentlich um die Harzgänge oft in die Quere gezogen, mit einfachen Tüpfeln, wo sie aneinander und an Markstrahlen grenzen, im übrigen vgl. das bei den Gefäszen bzw. dem Libriform gesagte. Die Tüpfel oft auf der Radialwand in 1 oder 2 vertikalen Reihen angeordnet. Interzellularen nicht erkennbar.

Harzgänge: Weite radial 30—90 μ, tangential 30—80 μ, darin gelegentlich braune Harztropfen.

Markstrahlzellen:

1. Liegende: Weite radial 30—80 μ, tangential 7—20 μ, Länge 10—40 μ, polygonale Prismen mit radialer Längsachse und abgerundeten Kanten, die tangentiale Wand meist senkrecht stehend, getüpfelt wie die Parenchymzellen.

2. Aufrechte: Weite radial 30—60 μ, tangential 10—20 μ, Länge 20—60 μ, mit längsgerichteter Achse, im übrigen wie die liegenden Zellen. Inhalt fast stets Harz, auszerdem sehr oft in den aufrechten, aber zerstreut auch in Hüllzellen und liegenden Zellen ein deutlicher, meist ± kleiner Einzelkristall, der in der Regel nur einen Teil des Zellinneren ausfüllt (Tafel, Fig. 4, 5).

Bestimmung des Holzes:

In der Beschreibung fehlen, gemessen an der „Linnean Method" von Moll und Janssonius, viele Einzelheiten. Das ist eine Folge der zum Teil mangelhaften Erhaltung des Fossils. Dennoch ist eine Bestimmung durchaus möglich. Charakteristische Merkmale sind die Markstrahlen, das Parenchym und die Harzgänge, die erkennen lassen, dasz in dem Holz eine Dipterocarpaceenart vorliegt. Solche waren auch unter dem Djambimaterial (Kräusel 1) häufig; sie sind als *Dipterocarpoxylon Tobleri*, *Dipterocarpoxylon* sp. (? *Tobleri*) und *Dipterocarpoxylon* sp. beschrieben worden. Dazu tritt noch *Dipterocarpoxylon burmense* Holden, und es konnte schlieszlich gezeigt werden, dasz auch *Grewioxylon Swedenborgii* Schuster sowie *Woburnia Scottii* Stopes zu *Dipterocarpoxylon* gestellt werden müssen, von denen die erste Art *Dipterocarpoxylon Tobleri* recht nahe steht, aber höhere Markstrahlen und gefächertes Holzparenchym besitzt.

Sehen wir von *Dipterocarpoxylon Scottii* aus der unteren Kreide Englands ab, das wegen seiner anders verteilten Harzgänge und der im übrigen ± mangelhaften Erhaltung für den Vergleich mit dem

vorliegenden Fossil nicht in Frage kommt, so sind alle diese Hölzer auf Südostasien beschränkt. Mit keinem kann das Holz von Bolang vereinigt werden. *Dipterocarpoxylon burmense* besitzt einreihige Markstrahlen, *Dipterocarpoxylon* sp. viel gröszere Gefäsze und häufigeres zerstreutes Parenchym, *Dipterocarpoxylon Swedenborgii* viel höhere Markstrahlen (bis 80 Zellen hoch) und teilweise gefächertes Parenchym. *Dipterocarpoxylon Tobleri* schlieszlich stimmt in allgemeinen zwar mit unserem Holz gut überein, doch ergeben sich für dieses folgende Unterschiede: Alle Elemente sind relativ viel kleiner, das wird vor allem deutlich bei Gefäszen, Harzgängen, Höhe und Breite der Markstrahlen. Wenn auch diese Verhältnisse innerhalb einer Art individuellen Schwankungen ausgesetzt sind, so dürften derartige Unterschiede (die Weite der Harzgänge z. B. bei *Dipterocarpoxylon Tobleri* 100—300 μ, hier nur 30—90 μ), wo es sich doch unzweifelhaft um altes Stammholz handelt, systematisch bedingt sein. Namentlich der Tangentialschnitt mit den verhältnismäszig viel breiteren Markstrahlen bietet ein ganz anderes Bild. Dazu kommt in den Markstrahlen das häufige Auftreten von Einzelkristallen, die *Dipterocarpoxylon Tobleri* ebenso wie anscheinend allen anderen bisher beschriebenen Formen durchaus fehlen. Dass es sich hierbei nicht um etwaige schlechte Erhaltung handeln kann, ist bereits betont worden (Kräusel 1). Das vorliegende Fossil, dessen Gewebe viel schlechter erhalten ist als das eines Teiles der Djambihölzer, zeigt aufs Neue, dass gerade die Kristalle, wenn überhaupt vorhanden, auch sehr gut erkennbar bleiben.

Es ist eine neue Form, die als

Dipterocarpoxylon javanense

bezeichnet werden soll.

Mit einer bestimmten lebenden Art kann das Fossil bei dem derzeitigen Stande der anatomischen Holzuntersuchung kaum identifiziert werden. Es sei auf das an anderer Stelle gesagte (Kräusel 1) verwiesen. Auszuschliessen dürfte die Gattung *Dipterocarpus* selbst sein, bei der die Markstrahlkristalle nach allen bisherigen Untersuchungen fehlen. Sie finden sich dagegen sicher bei Arten von *Hopea* und *Vatica*. Auch Moll und Janssonius (1 I 347 u. f.) geben sie nur für *Hopea fagifolia* Miq. und *Vatica bancana* Scheff. an, wo sie aber nur in den aufrechten Markstrahlzellen auftreten. Jedoch fehlen beiden Zuwachszonen und *Vatica bancana* auch die tangentialen Harzgangreihen, wozu noch manche kleinere Unterschiede kommen. Nach alledem handelt es sich bei dem Fossil also vielleicht um eine *Hopea*-oder *Vatica*-art. Gerade die Häufigkeit und

Verteilung der Harzgänge scheint ja ziemlich groszen Schwankungen innerhalb der einzelnen Gattungen zu unterliegen.

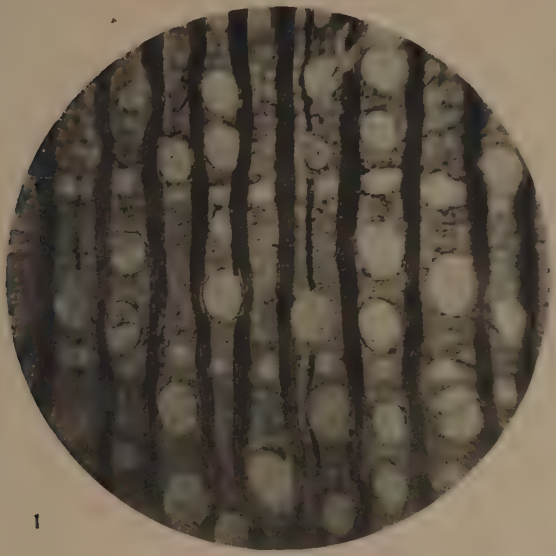
Die bisher bekannt gewordenen Dipterocarpoxyla sind tertiären Alters, und dies gilt wohl auch für *Dipterocarpoxylon javanense*. Kieselhölzer sind ja im Tertiär des ganzen Gebietes weit verbreitet, und schon Goeppert (1) hat solche in seiner Tertiärflora von Java abgebildet, ohne dasz allerdings seine Bilder eine Bestimmung der Hölzer ermöglichen würden.

Immer wieder zeigt sich also, dasz die Dipterocarpaceen auch im Tertiär in Südostasien weit verbreitet waren. Wir gehen daher in der Annahme kaum fehl, dasz sie schon damals eine ähnliche Rolle wie heute in der Flora des Gebietes gespielt haben, dasz diese also verhältnismäsig geringe Veränderungen vom Tertiär bis zur Jetztzeit durchgemacht hat.

Zum Schlusse mögen noch die bisher bekannt gewordenen fossilen Dipterocarpaceenhölzer in Form einer Tabelle zusammengestellt werden.

DIPTEROCARPOXYLON Holden.

1.	*a*) Markstrahlen ohne Kristalle	2
	b) Markstrahlen mit Kristallen	*D. javanense* (Tertiär? Bolang, Java).
2.	*a*) Markstrahlen mehrreihig	3
	b) Markstrahlen einreihig	*D. burmense* (Tertiär, Burma).
3.	*a*) Harzgänge in (±) langen tangentialen Parenchymbändern	4
	b) Harzgänge nur sehr zerstreut	*D. Scottii* (untere Kreide, England).
4.	*a*) Neben den tangentialen Reihen auch zerstreute Harzgänge	5
	b) Neben den tangentialen Reihen keine zerstreuten Harzgänge	*D.* sp. (Tertiär, Sumatra).
5.	*a*) Die tangentialen Harzgangreihen sehr lang	6
	b. Die tangentialen Harzgangreihen kürzer, oft unterbrochen	*D.* sp. (*Tobleri*?) (Tertiär, Sumatra).
6.	*a*) Markstrahlen bis 80 Zellen hoch, die Einzelzellen bis 140μ hoch (gefächertes Parenchym)	*D. Swedenborgii* (Tertiär, Ostindien).
	b. Markstrahlen bis 50 Zellen hoch, die Einzelzellen bis 90μ hoch (einfaches Parenchym)	*D. Tobleri* (Tertiär, Sumatra).



1

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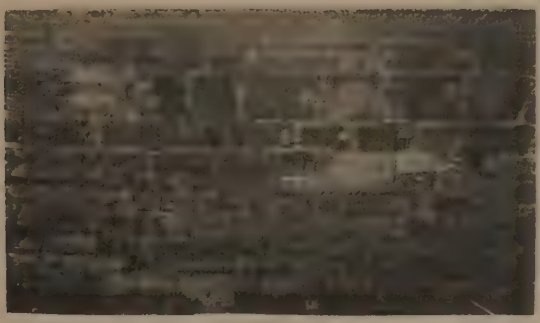

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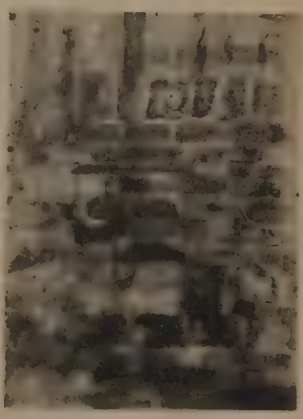
2



5

Kräusel phot.

Heliotype van Leer, Amsterdam

Die Zahl der bisher untersuchten fossilen Hölzer des Gebietes ist angesichts der Häufigkeit ihres Vorkommens verschwindend gering, obwohl sie einen wesentlichen Beitrag zur Kenntnis der fossilen Flora liefern würden.

ABBILDUNGEN.

Textfig. 1. Querschnitt, Uebersichtsbild.

Tafel, Fig. 1. Desgleichen. Markstrahlen, Gefässe, tangentiale Holzparenchymbänder mit Harzgängen. $^{25}/_{1}$.

Tafel, Fig. 2. Desgleichen. $^{55}/_{1}$.

Tafel, Fig. 3. Tangentialschnitt. Verteilung der Markstrahlen. $^{25}/_{1}$.

Textfig. 2. Desgleichen. $^{50}/_{1}$.

Tafel, Fig. 4, 5. Radialschnitt. Aufrechte und liegende Markstrahlzellen, teilweise darin Harz und Kristalle. $^{150}/_{1}$.

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Anatomy. — "*On the Significance of the Supra-orbital Ridges in the Primates.*" By Prof. L. Bolk.

(Communicated at the meeting of February 25, 1922).

The significance of any morphological feature may be gathered either from the function it performs, or from its mode of origin. Of these two methods it is always best to follow the first and to employ the second only when the first fails or yields unsatisfactory results. That the first method yields more reliable results is substantiated by the fact that in the application of this method direct observations are the basis for our conclusions, which in the other case are supported at best by more or less plausible reasoning and speculation about the possible influences and correlation of phenomena.

What I wish to state about the significance of the supra-orbital ridges in the Primates I have preceded by this contrast between the two methods of scientific morphological research, since not long ago the same subject was raised at one of our meetings by our fellow-member Prof. Dubois, who chiefly adopted the second method. I also propose to discuss the question of the supra-orbital ridges of the Primates — about which I pronounced my opinion on a previous occasion. However, in my discourse I will scrupulously keep within the bounds of immediate observation.

First of all let us consider the facts. When comparing the human skull with that of Anthropoids — to which group I will confine myself for the time being — we are struck at once by the difference in contour where the cerebral crane passes into the facial skull. That this difference is accentuated by the orthognathy of the human skull as contrasting with the marked prognathy of the Anthropoid skull, is only of secondary importance for our problem. The Anthropoid skull has no external frontal vault, which is the reason why some consider this skull to be flattened. This belief may be supported by the comparison of young Anthropoid skulls with those of adults. In the former the supra orbital ridges are absent, which makes the skull look much more like that of man. The ridges are formed as the ape grows up. This development commences shortly after the complete eruption of the milk set about the time when the first permanent molar appears.

Now what is the function of these supra-orbital ridges? To find the answer the researcher should ascertain the part played by these ridges in the structure of the skull as a whole, and what is their topographical relation to their immediate surroundings. This may be done quickest by making a sagittal section that extends along the axis of the orbit, through the ridge and the adjoining part of the skull. The image resulting from it is represented for Gorilla in fig. 1.

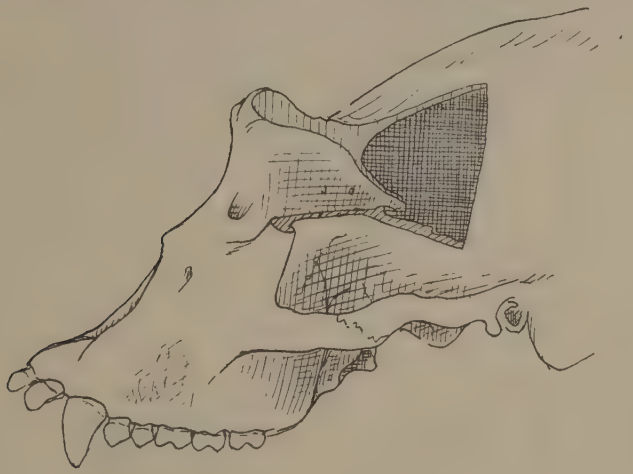
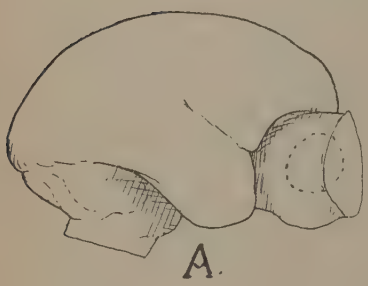


Fig. 1.

What does this figure teach us? First of all that, properly speaking, the term supra orbital ridge is not quite fit and that this formation cannot be compared with the occipital-, and the sagittal ridge also characterizing the skull of Gorilla. For, in reality, of this so-called supra-orbital ridge the lateral portions form the roof of the orbits, while the central part forms the roof of the nasal cavity. If, therefore, the supra-orbital ridge should be removed, nearly the whole content of the orbita would be deprived of the overlying osseous wall and would consequently come to lie immediately under the skin.

Direct observation of the topographical relation, therefore, leaves no manner of doubt about the function of the so-called supra-orbital ridge, it is namely the indispensable osseous wall of the orbita at the top. It is not a crest like the crista sagittalis and the crista occipitalis, but it is an indispensable wall of a cavity in the skull. But if this is a fact the origin of the superorbital ridge must be closely allied to general growth-phenomena of the skull after the early childhood of the ape. For we stated that, notwithstanding the absence of the supra-orbital ridges in the child-ape, still also here

the orbita is provided with an osseous roof. It is a fact, indeed, that in this part of the skull radical changes have taken place in the topographical relations. These changes may be summarized as follows: in the child-anthropoid, and a fortiori in the fetus, the orbits are situated under the cranial cavity, whereas in the adult they are for the greater part precerebral. While they are lying under the cranial cavity the bottom of this cavity makes up the roof for the orbits, but when the orbitae are shifted precerebral a new roof is to be formed for an adequate protection of the contents. That we really have to do here with a displacement of the whole content of the orbita anteriorly and not with a simple enlargement of the orbitae, is illustrated by Figs 2 and the folllowing. They represent casts of the cranial cavity and orbita, in situ.



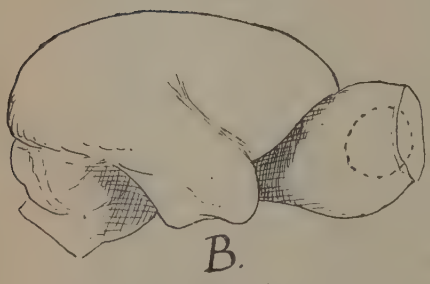
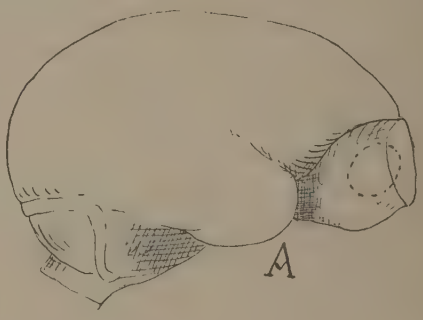


Fig. 2.



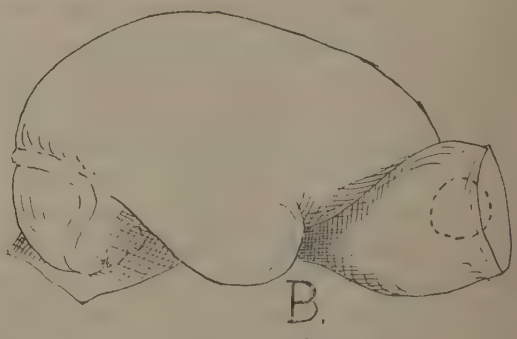


Fig. 3.

These casts were made in the following way: Copper wire of adequate thickness was stuck through the communications between orbit and cranial cavity; subsequently the orbit and the cranial cavity were filled with plaster of Paris. Finally the enclosing skeleton was cautiously removed with a chisel. In this way an exact image is obtained of the topographical relations between the cranial cavity and the orbita.

Fig. 2A represents a cast of the cranial cavity and orbita of a young Macacus cynomolgus, Fig. 2B those of an adult specimen. A dotted line indicates the location of the eye-ball. When comparing the two figures, the difference between the young and the adult specimen as to topographical relation of the orbita and consequently of the eyeball, is quite obvious. In the young specimen the eyeball is still subcerebral, in the adult it is on the other hand precerebral.

The same holds for Siamanga syndactylus, though in a smaller degree than for Macacus, as will be seen in Fig. 3A (young animal) and 3B (adult). Here the anterior displacement of the orbit during growth is not so considerable as with Macacus, which accounts for

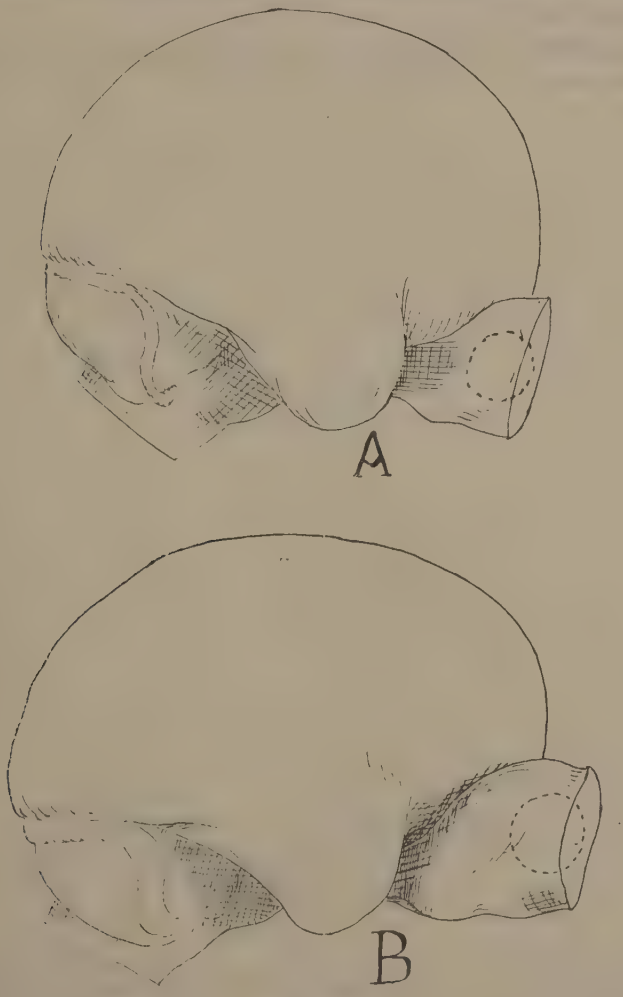


Fig. 4.

the fact that in Gibbon the so-called supra orbital ridge is less developed than in Macacus.

This is the case in a still smaller measure in Orang, as appears from a comparison between fig. 4A and 4B. Although we distinctly observe here an anterior shifting of the orbita, it is only slight. This is why in Orang no supra-orbital ridges have been developed, but only a general thickening of the frontal bone immediately over the orbitae.

A comparison of the figures 2, 3, and 4 inter se clearly shows the causal correlation between the origin of supra-orbital ridges and the shifting of the orbitae, for the less this shifting, the less strong the ridges will be.

This appears even more distinctly from a comparison of Fig. 5A and Fig. 5B.

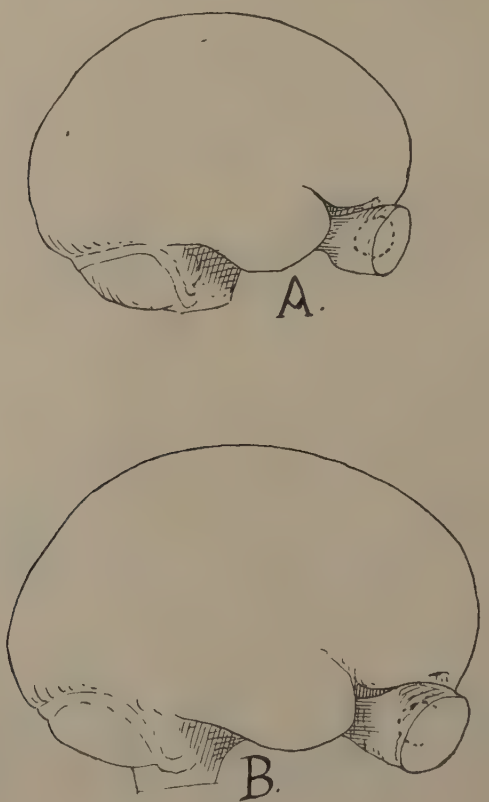


Fig. 5.

Fig. 5A shows a cast of cranial cavity and orbita of a one-month-old child, and Fig. 5B that of an adult man. It will be seen

that there is no question about a displacement of the orbita, in the baby as in the adult the orbita is situated subcerebral, which accounts for the complete absence of supra-orbital ridges in man.

The subcerebral position of the orbitae is a typical feature of the human skull, by which it is distinguished from all other mammalian skulls. In this respect the Orang skull is most like that of man. Parenthetically I call attention to my former pronouncement, quite in harmony with the fact established here: that all typical human somatic properties are persisting fetal features.

The Figures 4A and 4B also induce me to say something relative to the so-called flattening of the skull of Anthropoids. The hypothesis that the skull of Anthropoids has been flattened through mechanical causes, I consider, in principle, erroneous, as it is based only on deficient observation and inaccurate measurement. As to the latter it must be considered as a fundamental error when, in determining the length-height-index of the skull, the greatest length of the skull is considered to be the distance between two points lying on the outside of the skull. According to this method the height of the skull should be measured from the basion to the superior margin of the crista sagittalis. For a comparison of the forms of skulls of allied species measures should be used that cannot be influenced by a difference in thickness of the cranial bones, or by other adventitious circumstances. Points on the inside of the skulls should be used.

But the hypothesis that the Anthropoid skull is flattened, rests on deficient observation, as stated above. A flattening of the skull would necessarily entail a transformation of the cranial cavity. Now when comparing the relative figures it will be seen that in Macacus the brains of the adult individual with his large supra-orbital ridges are not flatter than those of the young individual, in which the ridges were lacking; it will furthermore be seen that the cranial cavity of the adult Orang in the frontal region is still as much vaulted as in the young specimen.

The anthropomorphous child has a frontal vault that is visible on the outside. The absence of this vaulting in the adult skull is not to be ascribed to a flattening, undergone by the frontal region, but is due to a shifting of the orbits anteriorly and to their consequent precerebral situation. From the vaulted front a new roof overlaps the orbita, and the originally apert frontal vault has thereby become an occult one.

Mathematics. — *"Representation of a Bilinear Congruence of Twisted Cubics on a Bilinear Congruence of Rays."* By Prof. JAN DE VRIES.

(Communicated at the meeting of February 25, 1922).

In a communication entitled: Congruences of Twisted Cubics in connection with a Cubic Transformation (these Proceedings Vol. XI, p. 84, 1908) I have shown that the congruence of the twisted cubics ϱ^3 through five points (congruence of REYE) may be converted by a simple transformation ($x_k y_k = 1, k = 1, 2, 3, 4$) into a sheaf of rays. Now I *shall* show how a different congruence $[\varrho^3]$ likewise by means of a cubic transformation, may be represented on a bilinear congruence of rays.

§ 1. The transformation in question arises in the following way. Three crossing straight lines a_1, a_2, a_3 are the axes of involutions of planes with pairs $\alpha_k, \alpha'_k\,(k = 1, 2, 3)$; to the point of intersection P of the planes $\alpha_1, \alpha_2, \alpha_3$ the point of intersection P' of the corresponding planes $\alpha'_1, \alpha'_2, \alpha'_3$ is associated.

For a point A_1 of a_1, α_1 is indefinite; any point of the straight line t_{23} which is the line of intersection of the planes α'_2, α'_3 corresponding to A_1, may be considered as the image of A_1. To the points of the *singular* straight line a_1 the rays of a quadratic scroll $(t_{23})^2$ having a_2 and a_3 as directrices are therefore associated.

Let t be a transversal of a_1, a_2 and a_3, S the point of intersection of the three planes α'_k associated to the planes $\alpha_k \equiv ta_k$. Evidently S is associated to every point of t. The locus of the *singular* points S is a twisted cubic σ^3, each point of which is represented by a ray of the quadratic scroll $(t)^2$ having a_1, a_2 and a_3 as directrices.

S being especially associated to the points A_1, A_2, A_3 where t rests on a_1, a_2, a_3, σ^3 is the partial intersection of the three scrolls $(t_{23})^2, (t_{31})^2, (t_{12})^2$; these have in pairs a straight line a_k in common.

When P describes the straight line r, the pencils (α_k) become projective; also the pencils (α'_k) become projective and they produce a twisted cubic ϱ^3 which is the image of the straight line r. As r

cuts two rays of each of the scrolls $(t_{kl})^2$, ϱ^3 has the straight lines a_k as chords; it rests in two points on σ^3 because r meets two rays t.

Let us now consider the *bilinear congruence of rays* $[r]$ which has two of the straight lines t an directrices. Through the cubical transformation it is transformed into the congruence $[\varrho^3]$ of which the curves ϱ^3 pass through two fixed points S_1 and S_2 and have the three fixed straight lines a_1, a_2, a_3 as bisecants [1]).

Inversely any congruence $[\varrho^3]$ with two base points S_1, S_2 and three fixed bisecants a_k can be represented on a bilinear congruence $[r]$. With a view to this we take two transversals t_1, t_2 of the straight lines a_k and we define the involution of planes through a_k by associating the planes $(a_k S_1)$ and $(a_k S_2)$ to the planes $(a_k t_1)$ and $(a_k t_2)$.

§ 2. The curve ϱ^3 degenerates as soon as the ray r rests on one of the singular lines σ^3 or a_k.

If r passes through the point S of σ^3 its image is composed of the straight line t associated to S, and a conic ϱ^2 through S_1 and S_2 cutting a_1, a_2 and a_3. The locus of the conics ϱ^2 is the dimonoid of the fourth order, Δ^4, which has threefold points in S_1 and S_2, contains the straight lines a_k and has a double torsal straight line $S_1 S_2$.

The image of Δ^4 is the scroll $(r)^6$ with directrices ϱ^3, t_1 and t_2, where t_1 and t_2 are threefold, which has the straight lines a_k as double generatrices. This may be verified by combining $(r)^6$ with a curve μ^3, which is the image of a straight line m.

If the ray r is to rest on a_1, it must belong to one of the plane pencils having the points $B'_1 \equiv a_1 t_1$ or $B''_1 \equiv a_1 t_2$ as vertex and belonging to the bilinear congruence of rays (1, 1). The former plane pencil lies in the plane $B'_1 t_2$; the image of this plane is the scroll $(t_{22})^2$ combined with the plane $S_2 a_1$. For $[\varrho^3]$ there is found from this a pencil of conics which have S_2 and the intersections of a_2 and a_3 with the plane $S_2 a_1$ ase base points. The fourth base point is the intersection with the straight line b'_{23}, which, as a transversal through S_1 of a_2 and a_3, is the image of the point B'_1. Here we have therefore a group of degenerate figures each consisting of the straight line b'_{23} and a conic of the pencil in question.

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[1]) This congruence has for the first time been investigated by M. STUYVAERT (Dissertation inaugurale, Gand 1902). A different treatment of the "Congruence of STUYVAERT" is found in the thesis for the doctorate of J. DE VRIES, Utrecht 1917, where also the literature on bilinear congruences of twisted cubics is mentioned.

There are of course *five* more analogous groups represented by the plane pencils having their vertices in $B''_1, B'_2, B''_2, B'_3, B''_3$.

§ 3. A degeneration into three straight lines is represented by a ray of (1, 1), which cuts the singular lines twice. This is among others the case with the bisecant d of σ^3 which rests on t_1 and t_2 (and differs from a_1, a_2, a_3). Its image consists of the straight line $d_{12} \equiv S_1 S_2$ and the two transversals t' and t'' that rest on d_{12}, a_1, a_2 and a_3 and that are the images of the points were d rests on σ^3.

The image of the ray $B'_1 B''_2$ consists of the line of intersection of the planes α'_1 and α'_2 corresponding to the planes $\alpha_1 \equiv a_1 B''_2$ and $\alpha_2 \equiv a_2 B'_1$ and of the straight lines b'_{23} and b''_{13}. Through combination of the points B'_k and B''_l we find in this way *six* configurations ϱ^3 formed by three straight lines.

The straight line b'_{23} lies on Δ^4; together with S_2 it defines a plane; the straight line in this plane through S_2 intersecting a_1 forms together with b'_{23} and the straight line t resting on it a configuration ϱ^3.

There are apparently five analogous configurations; the congruence $[\varrho^3]$ contains accordingly in all *thirteen* of those figures, each consisting of three straight lines.

§ 4. The curves of $[\varrho^3]$ resting on a straight line l, are represented by the straight lines r of the (1,1), which cut a curve λ^3 that has a_1, a_2, a_3 as chords and that meets σ^3 twice. These straight lines r form a scroll of the sixth order, $(r)^6$, with threefold directrices t_1, t_2 and double generatrices a_k. The straight line r_0 which is a chord of λ^3, hence a double generatrix of $(r)^6$, has for image a curve ϱ_0^3 that meets l twice and which is therefore a double curve of the image of $(r)^6$. As therefore an arbitrary straight line is cut twice by only *one* ϱ^3, $[\varrho^3]$ is a *bilinear* congruence.

The image μ^3 of a straight line m has four points on a_1 in common with $(r)^6$, for this curve cuts the double straight line a_1 in two points. Besides the straight lines a_k μ^3 and $(r)^6$ have six more points in common; hence the image of $(r)^6$ is a surface of the sixth order, A^6, with three double lines, a_k, and the double curve ϱ_0^3.

If μ^3 passes through a point of the line t_1 (which is threefold on $(r)^6$, m contains only three points of A^6 outside the singular lines; here S_1 and S_2 are therefore threefold points.

On A^6 there lie also the six lines b (§ 2) as component parts of the degenerate figures of which the conics ϱ^2 rest on l.

§ 5. The transformation used here, gives also the representation of *another* congruence $[\varrho^3]$. Let us consider the image of the sheaf that has M' for centre. A ray r' through M' cuts each of the scrolls (t^2) and $(t_{ik})^2$ twice and is therefore the image of a curve ϱ^3 through the fixed point M that cuts σ^3 and the lines a_k twice. This $[\varrho^3]$ is a special case of a congruence described by VENERONI [1]).

Through a point there passes *one* ϱ^3 of this congruence. A curve μ^3, the image of a straight line m, sends *one* chord through M'; hence m is a chord of *one* curve ϱ^3. Also this $[\varrho^3]$ is therefore *bilinear*.

If r' intersects the curve σ^3, ϱ^3 consists of a straight line t and a ϱ^2 through M, which intersects σ^3 twice and which rests on a_1, a_2, a_3 and t. The cone k^3 projecting σ^3 out of M', has two points of σ^3 in common with a μ^3; there are accordingly seven ϱ^3 resting on m. The conics of the degenerate figures in question form therefore a surface ψ^7; on this a_1, a_2, a_3 are double lines (each straight line t defines *one* point S, hence one ray $M'S$, and cuts ψ^7 for this reason besides in a_k in one more point) and σ^3 is a threefold curve (t meets three generatrices of k^3).

The surface ψ^7 is represented on a plane by the chords of σ^3; it is therefore a rational surface and belongs to the group of homaloids to which I have drawn attention in a communication of Vol. XX, p. 419 of these Proceedings.

If r' rests on a_1, ϱ^3 degenerates into a straight line t_{23} (the image of the point $a_1 r'$) and a ϱ^2 of the plane α corresponding to the plane $\alpha' \equiv M' a_1$. The conics ϱ^2 form a pencil with base points M, the points A_2 and A_3 of a_2 and a_3, and the intersection of α with σ^3, which point does not lie on a_1. Each ϱ^3 is connected with a straight line t_{23} and this rests on a_2, a_3 and σ^3.

There are accordingly in all *four* systems of compound figures ϱ^3.

The chord of σ^3 passing through M', is the image of a ϱ^3 composed of two straight lines t and the straight line through M which cuts them and which is at the same time a chord of σ^3.

The transversal of a_1 and a_2 through M' is the image of a ϱ^3 formed by a straight line t_{23}, a straight line t_{13} and their transversal through M which rests at the same time on a_1 and a_2.

The transversal through M' of a_1 and σ^3 is the image of a ϱ^3 formed by a straight line t, a straight line t_{23} and their transversal through M which rests at the same time on a_1 and on σ^3.

There are therefore in all *seven* figures ϱ^3 consisting of three straight lines.

[1]) Rend. Palermo XVI, 209.

The curves ϱ^3 resting on a straight line l, are represented by the generatrices of the cone that projects the curve λ^3 out of M'. As this cone is cut by a μ^3 in nine points, the curves ϱ^3 intersected by l form a surface A^9. On this surface a_1, a_2, a_3 and o^3 are threefold lines, because any straight line t_{kl} and any line t cuts the cone (M', λ^3) three times and the image of the double generatrix of this cone is a double curve of A^9. Any curve of $[\varrho^3]$ has 8×3 points in common with A^9 on the singular lines; hence M is a triple point of A^9.

Physics. — "*Research by means of Röntgen-Rays on the Structure of the Crystals of Lithium and some of its Compounds with Light Elements.* II. *Lithium-Hydride*". By J. M. BIJVOET and A. KARSSEN. (Communicated by Prof. P. ZEEMAN).

(Communicated at the meeting of February 25, 1922.)

1. *Introduction.* The investigation with X-rays on the structure of lithium-hydride was taken up in connection with the analogy drawn by MOERS [1]) between lithium hydride and the heteropolar alkali halogenides.

2. *Röntgenograms.* The photographs were made as described in our preceding paper [2]). The difficulty presented itself that after the exposures the hydride-content had been reduced by 15 or 20 percents of weight. The parasitical lines were eliminated: by comparing the photographs of samples of decreasing hydride-content (the place of the LiH-lines appeared to be independent of the degree of decay, hence no formation of mixed crystals); by photographing a coarse crystallized, non-rotated sample, appearing the interference lines of LiH markedly distinguished by dots of greater intensity; by checking up the parasitical lines by those of LiOH).

3. *Calculation.* The table contains for LiH the values of $10^3 \sin^2 \frac{\vartheta}{2}$ for the centres of the α-lines. As appears from the occurrence of a factor $77{,}5 \pm 0{,}5$ LiH is regular, and the side of the elementary cell $a = 4$, $10 \,.\, 10^{-8}$ cm. From this common factor the number of particles per elementary cell, n is calculated to be 4.30, with the aid of the density according to MOERS, mol.weight, constant of AVOGADRO, and wavelength $Cr_{K\alpha}$ (resp. 0,816; 7,94; 0,6062 . 10^{24} and 2,284 .10 [8]). This points to $n = 4$, which is in agreement with the supposed NaCl structure together with the absence of the planes of mixed indices.

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[1]) MOERS, Z. f. allg. u. anorg. Chem. **113**, 179, (1920).
NERNST, Z. f. Elektrochemie **26**, 323 and 493 (1920).

[2]) BIJVOET and KARSSEN. These Proceedings Vol. XXIII, p. 1365.

Putting $n = 4$ the said common factor determines the density at $0{,}76 \pm 0{,}01$[1]). In absence of all further crystallographical data we have confined ourselves to the question whether sticking to a NaCl or ZnS structure an electron grouping could be found, according to the intensities of the reflections found.

The table gives the observed and calculated intensities. Only those factors which bring about an abrupt change in the intensity as function of Σh^2, have been taken into account, viz. the factor of the number of planes and the structure factor, in which the influence of the configuration of the electrons too has been accounted for. For this were tested some approximative suppositions. We have considered the possibility that the valency-electron remains near its mother-nucleus (atomic lattice); that the Li has lost its valency-electron to the hydrogen (ion lattice)[2]); that binding of Li and H takes place by means of rings of electrons revolving round the connecting line in planes normal to the non intersecting trigonal axes halfway the Li and H nuclei (binding circles; passing along a trigonal axis two-electron-rings may be imagined between Li and H: molecular lattice, case A; or one-electron-rings between Li and H as well as between H and Li, case B).

As to the orbits of the electrons it has been assumed: 1. that the electrons are so near to their nucleus that they may be supposed to lie in one point (points; reflecting power proportional to the number of electrons); 2. that the connecting line of nucleus and electron is of a definite length ϱ, and is equally occuring in all orientations throughout the part of the crystal that is cooperating in the interference (spheres; diminishing factor for such an electron $\frac{\sin 2\pi \frac{\varrho H}{a}}{2\pi \frac{\varrho H}{a}}$, in which $H = \sqrt{\Sigma h^2}$[3])); and 3. that these connecting lines are in planes normal to the non-intersecting trigonal axes, all the directions equally occurring in those planes (rings: diminishing factor $J_0\left(2\pi \frac{\varrho H}{a} \sin \gamma\right)$, in which J_0 is the Bessilian-function of the order of magnitude 0 and γ the angle between orbit and lattice plane[4]). In the binding circles also only circular orbits have been

[1]) Impririties have no influence on this value of the densty, as there is no formation of mixed crystals.

[2]) Also the less probable case Li−H+ has been considered.

[3]) Cf. Kolkmeyer, These Proc. Vol. XXIII N°. 1, p. 120.

[4]) Cf. Coster, These Proc. Vol. XXII N°. 6, p. 536.

Number.	$10^3 \sin^2 \frac{\vartheta}{2}$ (observed).	Plane indices.	Observed Intensities	Calculated Intensities.														
				Points.				Spheres [1].				Rings [1].				Binding-circles.[2]		Rings. [3]
				NaCl-str.		ZnS-str.		NaCl-str.		ZnS-str.		NaCl-str.		ZnS-str.		NaCl-str.		NaCl-str.
				ions.	atoms.	i.	a.	i.	a.	i.	a.	i.	a.	i.	a.	A.	B.	i.
1	232	*111*	z	0	32	64	80	7	26	36	52	7	26	37	53	37	32	10
2	312	*200*	ms	96	96	0	24	40	51	8	18	38	50	9	18	16	16	30
3	616	*220*	ms	192	192	192	192	36	56	36	56	38	57	38	57	39	39	35
4	853	*311*	zs	0	96	192	240	94	55	70	64	99	54	71	62	102	96	70
5	934	*222*	s	128	128	0	32	14	21	31	17	19	56	25	19	34	35	42

[1]) In this according to BOHR, Phil. Mag. [VI] **26**, 490 (1913).
Radius inner ring Li = 0.20 Å
„ outer ring Li = 0,65 „
„ H -ring = 0,55 „
„ H^--ring 0,73 „

[2]) $\rho = 0{,}2$ a

[3]) In this
Radius Li^+-ring = 0,05 a
„ H^--ring = 0,6 a

considered, and here too relation of phases has been neglected (diminishing factor as under 3).[1])

The influence of the heat motion, of which nothing is known for the different electrons, was left out of consideration. The radius of the comparatively small inner ring of Li has always been taken equal to BOHR's initial value[2]); in all the suppositions mentioned it has been examined what values of the radii of the other orbits made the calculated and observed intensity concordant. Finally the supposition "rings, $\varrho_{II} - = \pm 5/6$ times the radius of a two-quanta ring in a free H -ion" appeared to give the best agreement. As a specimen some of the calculated intensities are given i. a. those for BOHR's initial values of ϱ, and in the last column the case $\varrho_{II} - = \pm 0{,}6a$ and $\varrho_{Li+} = \pm 0{,}05a$, which is in agreement with the observations.

In how far the factors neglected here, as heat motion, and the occurrence of non-circular orbits, may affect the conclusions drawn here, must at present be left undecided.

4. *Summary.* The Röntgenogram of lithium hydride (method DEBYE-SCHERRER) has been taken with K_{Cr} rays. LiH appears to crystallize regularly with 4 LiH per elementary cell. [Side $a = 4.10.10^{-8}$ cm.]. The density is found to be $0{,}76 \pm 0{,}01$. On the basis taken for the calculation the following assumptions appeared to be most satisfactory: NaCl-structure with positive Li-ions and negative H-ions; systems of two-electron rings both round Li- and H-nuclei with radii resp. $\pm 0{,}05a$ and $\pm 0{,}6a$, the planes of which are normal to non-intersecting trigonal axes.

In conclusion we express our great indebtedness to Prof. SMITS for his valuable help and the great interest he took in our work.

Laboratory of Physical and Inorganic Chemistry.
Amsterdam, February 15, 1922.

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[1]) In COSTER's computation of the binding circles of diamond this has also been introduced, whereas KOLKMEYER bases his calculations on an undisturbed phase relation.

[2]) BOHR, Phil. Mag. (VI) 26 490 (1913).

Bacteriology. — "*Studies about* D'HERELLE's *Bacteriophagus*". By J. W. JANZÈN and L. K. WOLFF. (Communicated by Prof. C. EYKMAN).

(Communicated at the meeting of February 25, 1922).

I. *The Bacteriophagus in Enteric Fever.*

We have succeeded in proving the existence of this bacteriophagus in the faeces of patients recovering from enteric fever, as has also been described by D'HERELLE.

If D'HERELLE's views are right, it must be possible to influence the process of enteric fever favourably by administering bacteriophagum antityphoideum.

We have tried this in three cases and perhaps we have observed a somewhat favourable result, but not a striking success. The explanation hereof might be found in the fact that this bacteriophagus did not happen to be adjusted at the bacterium, that caused the illness of these patients. We have considered it worth while to examine this systematically.

We have been able to make use of three bacteriophagus specimen, two of which were from the faeces of patients recovering from enteric fever, the third from the faeces of a healthy person who had had enteric fever forty years ago. We have examined the effect of the bacteriophagi as opposed to 17 typhoid strains, 15 of which came from the collection of the Laboratory for Hygiene, the two others from the blood of patients out of which the bacteriophagus had also been taken. We have steadily examined the clearing up of the broth, which has turned slightly turbid by typhoid bacilli 6 hours old from agarcultures, the checking of the growth of typhusbacilli in broth, and finally the formation of little islands on the agarplate(plages).

What can be the cause of this difference in behaviour?

It might be supposed that the uninfluenced typhoid strains would be so called resistent strains.

This would be possible for some strains that are not influenced by any of the three bacteriophagus strains (3, 8, 20).

But we also see that the bacteriumstrain which is influenced by one bacteriophagus is not influenced by the other, and vice versa.

TABLE.

1. Clearing up of the typhoid bacilli distributed in the broth.
2. Checking of the growth of typhoidbacilli.
3. Formation of little islands on the agarplate, on which some of the contents out of tube I has been smeared.

	Bacteriophagus Wi.			Bacteriophagus Sm.			Bacteriophagus Re.		
typhoidstrain	1	2	3	1	2	3	1	2	3
Sm.	±	++++	++++	++++	++++	++++	–	+	++++
Wi.	++++	++++	++++	±	–	–	–	–	–
1	–	–	–	–	+++	++++	–	+++	++++
3	–	–	–	–	–	–	–	–	–
8	–	–	–	–	–	–	–	–	–
9	++++	++++	++++	–	+++	++++	±	++	++++
15	–	±	++++	–	–	++++	–	++	++++
19	–	±	++++	–	–	++++	–	–	++++
20	–	–	–	–	–	–	–	–	–
23	++++	++++	++++	–	+++	++++	–	–	–
24	–	++	++++	–	–	–	–	–	–
25	++++	++++	++++	–	+++	++	–	+++	++++
26	++++	++++	++++	++	+++	++++	++	++++	++++
27	–	±	++++	–	–	–	–	–	–
29	–	++++	++++	–	–	–	–	–	–
31	–	±	++++	±	++	++++	–	++++	++++
32	++++	++++	++++	–	+++	++++	–	++	++++

Bacteriophagus Wi negative with regard to 1, 3, 8, 20
„ Sm „ „ „ „ Wi, 3, 8, 20, 27, 29
„ Re „ „ „ „ Wi, 3, 8, 20, 23, 24, 27, 29.

Bij agglutination with a highly agglutinating horseserum (Saxonian serum-works) no difference between the strains could be demonstrated, they all agglutinated to $^1/_{40000}$.

So it will be necessary to find or to prepare a bacteriophagus which also affects the negative strains.

For the time being we have not succeeded in vitro to adapt the bacteriophagus to these. So we shall have to wait until a new

bacteriophagus is found which fills up this gap, if need be we can then administer a mixture of the various bacteriophagi.

We have been able to convince ourselves that, with a dose of 10 cM. bacteriophagus per os, the bacteriophagus was already to be found the next day in the faeces of two typhoid patients who had not had it before.

D'HERELLE has proved that the bacteriophagus is not absorbed by foreign bacilli on which it has no effect.

Our bacteriophagus however was absorbed by living typhusbacilli who were not influenced in their growth by our bacteriophagus.

February 1922. *Amsterdam, Lab. for Hygiene of the University.*

Bio-Chemistry. — *"Experiments on Anaphylaxis with Azoproteins".* By K. LANDSTEINER. (Communicated by Prof. C. H. H. SPRONCK.)

(Communicated at the meeting of January 28, 1922).

In previous articles the writer described methods for producing immune sera, acting upon known chemical groups. These methods are based upon the use of antigens, consisting of proteins, which are chemically combined with substances of simple constitution.[1])

As already indicated, the question suggests itself as to whether anaphylaxis can be produced by these compounds and what is the action in anaphylaxis (sensitization and shock) and antianaphylaxis of each of the two components of the antigen, viz. the proteins and the simple substances combined with it. The significance of these problems for the theories of immunity and anaphylaxis and the knowledge of the condition of hypersensibility produced by simple substances is evident (cf. DOERR)[2]).

The experiments presented here[3]) form part of a series, the carrying out of which has been delayed because of external circumstances.

The guinea pigs were sensitized by means of azoprotein[4]) prepared from horse serum and p-arsanilic acid (1 gr. of atoxyl for 100 cc. of serum).

For the second injection an azoprotein formed by combining fowl serum and p-arsanilic acid was employed. The use of a number of other azoproteins was rendered difficult because of their toxicity when injected intravenously.

Results: It was found to be more difficult to produce the anaphylactic state with the substances mentioned above than with the proteins usually employed, and in the experiments to be described it was necessary to make three intraperitoneal injections, corresponding to 0.5 to 1.0 cc. of serum each, in order to produce considerable effects.

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[1]) Zeitschr. f. Immun. **26**, p. 258 (1917), Biochem. Zeitschr. **86**, p. 343 (1918).

[2]) DOERR, Schweiz, med. Wochenschr. 1921. No. 41.

[3]) Details will be given later.

[4]) l. c. Bioch. Zeitschr. **86**, p. 359.

In the case of 14 of the sensitized guinea pigs, the reinjection was made intravenously, using 1 to 2 cc. of azoprotein[1]) per 500 gram weight of the animals. 5 animals died within a few minutes, 3 showed severe, 5 slight manifestations of anaphylactic shock. Nine control animals showed no symptoms.

Five animals treated in the manner described showed no anaphylactic reaction after the intravenous injection of azo-compounds obtained by combination of tyrosin and p-arsanilic acid; the injection of azoprotein (fowl serum + p-arsanilic acid) made an hour later failed to produce shock. As a control experiment, in 3 animals an azo-compound of metanilic acid and tyrosin was used for the intravenous injection. These animals showed anaphylactic symptoms on the subsequent injection of azoprotein (fowl serum + p-arsanilic acid).

The results obtained demonstrate that guinea pigs previously injected with an azoprotein (horse serum + arsanilic acid), show anaphylactic reactions upon being reinjected with another azoprotein containing the same group, i.e. fowl serum + arsanilic acid; but they do not show such symptoms upon being reinjected with a compound of arsanilic acid and a substance of simple composition, i.e. tyrosin. The latter substance, on the other hand, seems capable of desensitizing the animals.

The Hague. *Laboratory of the "R. K. Ziekenhuis".*

[1]) Prepared as indicated in Biochem. Zeitschr. **86**, p. 362.

Physiology. — *"On the Causes of the Emigration of Leukocytes"* [1])

By K. J. Feringa. (Communicated by Prof. H. J. Hamburger.)

(Communicated at the meeting of February 25, 1922).

De Haan [2]) has suggested a method by which in a simple manner, without injuring the laboratory animal, large quantities of polynuclear leukocytes can repeatedly be obtained. He injected into the abdomen of his animals fluids such as a starch-solution in NaCl 0.9, and other harmless fluids and thereby obtained invariably a homogeneous emigration of polynuclear leukocytes.

My own investigations were performed systematically according to this method, with a number of liquids in order to demonstrate a definite chemical cause for the emigration of the leukocytes. I experimented on rabbits.

For shortness sake I will only summarize the results of these experiments.

Whatever liquids were injected (electrolytes, non-electrolytes, more or less physiological fluids such as Ringer's solution, ultra filtrate of serum, sterile serum, olive-oil or paraffin) the result was invariably an exudation with emigration of many leukocytes. The process of this emigration was the same in all cases. *From this I concluded that the emigration is not brought on by a specifically chemotactic influence exercised by definite substances upon the leukocytes.*

However, there was still a factor that had been left out of consideration, viz. the *concentration of the hydrogen-ions*, which recent inquiries have proved to play a prominent part in different manifestations of life.

I considered it rather interesting to ascertain the proceeding of the H-ion concentration in the injected liquid at various intervals after the injection.

We used for this purpose the *colorimetric method* and applied *phenol-red* and *cresol-red*, recommended by Clark an Lubs [3]).

Determinations were made in serum of venous blood and in normal

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[1]) A more detailed communication will appear elsewhere.

[2]) J. de Haan, i.a. Thesis. Groningen 1920.

[3]) Clark and Lubs, Journ. of bact. 2. *1*. 109, 191 (1917).

abdominal transudate; the pH of serum was slightly less than 7,6 and that of normal abdominal transudate 7,6.

When fluids were injected into the abdominal cavity, a pH of 7,2 invariably occurred in the exudation after a short time (± ¾ hour), no matter whether the injected fluid was acid or alkaline beforehand. This was the same for all injected substances, also for strongly buffered fluids, such as serum. Only the interval before a pH of 7,2 is reached, is somewhat longer. This also applied to oil and paraffin-injections, the centrifugalized fluid then presented a pH of 7,2.

It appears, then, that *a difference of pH from* 0,3 *to* 0,4 *exists between the blood and the exudation.* At the same time it appeared that emigration of polynuclear leukocytes results from the injection of the same fluids.

There is now every reason for correlating the constant occurrence of emigration with this constant phenomenon of the changed pH, which also always manifests itself, however different the injected fluids may be.

The question may be asked: in how far this differing H-ion concentration may be answerable for the emigration. I have endeavoured to solve this problem by maintaining artificially in the injected fluid a pH of 7,6 or a little higher, through the addition of alkali, and comparing the result obtained with a control-animal, in which the injected fluid was left to itself. I found from three such experiments that in the first case no emigration of polynuclear leukocytes ensued, which, however, revealed itself with the control-animal.

It is evident from these experiments that *the degree of acidity is, indeed, the causative factor of the emigration of the polynuclear leukocytes*; it being the only factor which has altered in the experiments mentioned.

We now have to go into the question in what manner this established difference in H-ion concentration with the blood can bring about the emigration. Presumable potential differences between fluids with various H-ion concentration are the first to suggest themselves; such potential difference might well effect a movement of cells in one direction, in casu an emigration. I am analogously reminded here of the well-known *cataphoretical phenomena* found i.a. by HÖBER and his pupils especially in red blood-corpuscles.

I thought it desirable by following the example of HÖBER to perform cataphoretic experiments with red bloodcorpuscles, with polynuclear leukocytes and with mononuclear leukocytes of the rabbit in order to ascertain whether they behaved differently towards

the galvanic current. This appeared not to be the case: all of them moved towards the anode, their charge was consequently negative. Through the addition of acid we managed to change their charges: when the pH was made less than 4.8, they moved towards the cathode.

In the body, where pH is always greater than 4.8, they will always be moved by the current towards the anode. This, then, does not afford an explanation of the various behaviour of the different kinds of blood-corpuscles in the case of exudation. However, we need not, on that account, exclude the possibility of the exudation of the polynuclear leukocytes being caused by a potential difference, as besides a potential difference other factors come into play, which may cause or prevent emigration, i.a. the surface-properties with regard to the capillary wall, and the ameboid mobility. Hence the passive cataphoresis becomes complicated on account of these surface-actions. These actions will vary the effect of the cataphoresis in different cells in accordance with their composition; even in the absence of emigration, the cataphoretic effect even on red blood-corpuscles will reveal itself in the considerable accumulation of blood-elements in the abdominal vessels.

Now I have tried to demonstrate potential differences between two fluids differing only in the H-ion concentration. To this end we made use of a so-called "*ölkette*". I succeeded in demonstrating with *benzaldehyd* and *benzylalcohol* as *oilphase*, potential differences between fluids with a pH of 7.2 and 7.6. When adding lecithin or a mixture of lecithin and cholesterol to the oilphase, the potential difference was considerably greater. An addition of cholesterol alone, however caused the potential difference to disappear altogether.

These experiments have proved it to be very probable, that *through the difference in pH there is also a difference in potential* between the circulating blood and the exudation. Preliminary experiments justified the same conclusion.

With non-polarisable electrodes we found that under normal conditions the blood is positive (however slightly) relative to the abdomen, while after the injection of a fluid into the abdomen, a reverse potential difference manifests itself. These experiments, however, will have to be prosecuted further.

Since we have seen that the bloodcorpuscles may be moved by electromotive forces, we are justified in assuming that under the influence of the difference in acidity between the blood and the exudation, which causes a potential difference, the polynuclear leukocytes are moved towards the exudation. The anomalous be-

haviour of the lymphocytes and especially the red blood-corpuscles, may, as stated above, be ascribed to other surface properties of these cells.

In conclusion we may state, therefore, that through injection of any fluid whatever, an increased prolonged acidity can be demonstrated at the place of injection, which may reasonably be assumed to give a certain direction to the ameboid movements of the leukocytes, which reveals itself in the constant occurrence of the emigration of the polynuclear leukocytes.

I may still add that in no case does the increased acidity exist longer than 18 hours, after the injection of aqueous fluids, but that it persists longer after oil injections; this is the reason why with oil the emigration lasts longer, as is borne out by all phenomena, i.a. the changes in the blood-formula, which cannot be gone into any further here. Neither can I expatiate here on the cause to which the increased acid formation itself is due. I can state only that there is no excessive accumulation of carbonic acid. The only factor we can take into consideration is a diminution of the normal reserve of alkali under the influence of the formation of acids other than carbonic acid.

Now it is of vital importance to know whether our conclusions regarding the emigration of leukocytes in sterile abscesses and exudations, also apply in general to every migration of leukocytes through the body, e.g. to the emigration of leukocytes in exudations of bacterial origin and to the emigration (normal and pathological) of the white bloodcorpuscles from the bone-marrow in the blood-circulation. Concerning the latter we are inclined to believe that normal supply of the polynuclear cells in the blood from the bone-marrow is also procured under the influence of a potential difference between bone-marrow and blood. It may also be possible that, when that supply from the bone-marrow proceeds abnormally, as in cases of *leukæmia*, the relation between the pH in the blood and the bone-marrow is altered. It also avails to know the reason why, in the case of fatal infections, the bone-marrow does not react on the stimulus of inflammation, why no leukocytes are transmitted to the nidus of the inflammation.

It may be also that without a potential difference between bone-marrow and blood or between blood and the nidus of inflammation, the emigration of leukocytes is impossible. It should at the same time be noted, whether the distribution of lecithin and cholesterol in the body may have influence on the generation of electric currents;

the significance of a proper relation of these substances for various functions of the body, has latterly been pointed out by several authors[1]). Furthermore we have also seen, that cholesterol, added to an intermediate phase between two fluids with different H-ion concentration, brought about an isolation which prevented an electric current. Such an insulator might, therefore, likewise prevent the occurrence of an electric current in the body.

Thus far I have been able to ascertain whether acidity plays a rôle only with regard to the abscesses in acute inflammation processes In analogy to what we have seen in the sterile exudations, it may be expected that in pus or exudations of inflammatory nature, in which polynuclear leukocytes predominate, there will be a pH considerably smaller than that of the circulating blood. If only mononuclear leukocytes occur in the exudations or in the pus, the pH will differ little or not at all from that of the blood or the blood serum. It may be presumed, therefore, that in acute suppuration-processes there is in the pus a much lower pH than that in the serum. In chronic cases of suppuration, especially when there are no polynuclear leukocytes, the difference in pH with the blood must be much smaller. Likewise in tuberculous pus, where only mononuclear leukocytes occur, we cannot expect a great difference in pH with the bloodserum.

The pH of human bloodserum was determined again by the colorimetric method. Here we met with great obstacles in the yellow colour, which is most often peculiar to serum and in the occasional excess of fat. In accordance with the values established by EVANS[2]) with indicators, we found also in the human serum a pH of $\pm$ 7.6.

Pus from an acute pleuraempyema was examined. The liquid centrifugalized from the pus, had a pH of 6.9. The ill-smelling pus contained many streptococci and beyond mononuclear- many polynuclear leukocytes and remains of them.

Pus from a chronic molar abscess with acute exacerbation had a pH of 7, beyond mononuclear leukocytes also many polynuclear leukocytes and remains of them occurred in the pus.

In a case of streptococci-meningites the cerebrospinal fluid had a pH of 7.3 and contained rather many leukocytes, of which 60 % were mononuclear and 40 % polynuclear. The next day another puncture was made, and the fluid derived from it, proved to be much more cloudy; the pH was then rather more than 7.2. The relative number of the various kinds of leucocytes had changed now, the mononuclear cells fetching only 5% and the polynuclear as much as 95%.

It appears, then, that in these investigations the pH found, agrees with the presence of polynuclear leukocytes in the pus or in the exudation.

SUMMARY.

1. To bring about *the emigration of leukocytes from the blood-*

[1]) Cf. c.a. BRINKMAN and VAN DAM, Studien zur Biochemie des Phosphatide und Sterine 1—3. Biochem. Zeitschr. bnd. 108, H. 1/3 1920.

[2]) C. LOVATT EVANS, The Journ. of Physiol. 54, p. 167 and 353.

circulation, chemotactic properties of definite substances do not come into play. The process of the emigration is the same, whatever may be the nature of the substances injected for the purpose of obtaining the exudation in the abdominal cavity. Neither can any special significance be attached to *fat and lipoids.*

2. As for the chemical composition of the obtained exudation, it appeared that in a short time it becomes about the same as that of the normal tissue-fluid.

3. *The injected fluid very soon reaches a higher degree of acidity relative to the blood and the normal tissue fluid*; independent of its being acid or alkaline when injected, a concentration of hydrogen ions of about pH 7,2 is produced, while the normal reaction of blood and tissue-fluid is 7,6.

4. *This higher acidity must be considered to be answerable for the emigration, since the emigration stays away, when the acid reaction is checked.*

5. In keeping with this fact also in inflammatory-abscesses, the reaction of the fluid relative to the blood is distinctly more acid.

6. It is possible *to consider the emigration as resulting from the potential difference* arising under the influence of the difference in concentration of H-ions between the blood and the injected fluid, in the sense of a *cataphoretic action.*

7. We call attention to the possibility, that also in other abnormal accumulations of leukocytes in the body, as in leukæmia, corresponding factors play a part.

February 23, 1922.

From the Physiological Laboratory of the Groningen State-Univ.

Geology. — *"Observations on the Incandescent Sand Flow of the Valley of ten thousand smokes."* By ROBERT F. GRIGGS. (Columbus, Ohio, U.S.A.)

(Communicated at the meeting of April 29, 1922).

Of the work done by the last expedition (1919) Dr. ESCHER has seen only the popular account in the National Geographic Magazine, September, 1921, Vol. 40 pp. 219—292. This account, written for the 725,000 members of the National Geographic Society, was manifestly not the proper place for a technical presentation of the detailed data which the geologist requires as the basis for his conclusions.

A more technical, though only preliminary, account giving more geological information has been published by Dr. C. N. FENNER, Petrologist of the cooperating party sent with the expedition by the Geophysical Laboratory of the Carnegie Institution, in the Journal of Geology, Vol. 28, pp. 569—606, 1920, under the title "The Katmai Region, Alaska, and the Great Eruption of 1912."

A further contribution by E. T. ALLEN, Chemist of the Geophysical party, dealing not directly with the Incandescent Sand Flow but with the "Chemical Aspects of Volcanism", appeared in the Journal of the Franklin Institute, Vol. 193, pp. 29—80, January, 1922.

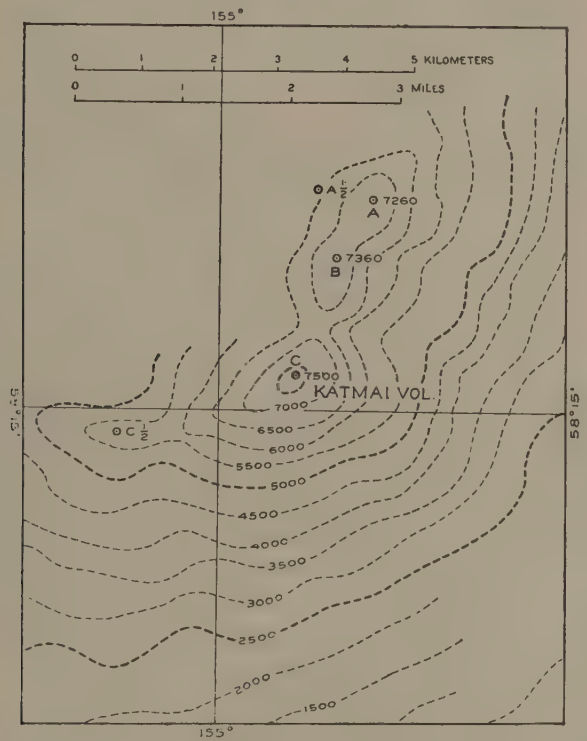
Further papers giving the scientific results of the Katmai expeditions in more detail are soon to appear in the projected Memoirs of the National Geographic Society.

Dr. ESCHER believes that the hot sand flow was made possible by the water of a crater lake which "must have" occupied the top of the mountain prior to the Eruption of 1912. He is in fact so sure of such a lake that he even figures it on his diagram.

The first and most obvious fact which renders this explanation impossible is that Katmai possessed no crater lake prior to the eruption. On page 43 is reproduced a section of the United States Coast and Geodetic Survey Chart N°. 8555 showing the condition of Katmai before the great eruption. It was a three-peaked mass without any large crater, essentially similar to its near neighbor Mageik, see map on page 45 also a photograph reproduced in the National Geographic Magazine, Vol. 31, p. 30, 1917. Both were rounded domes built up by repeated flows of viscous lava without admixture of cinders or other fragmental products such as appear in the typical composite cone.

Up till the last eruption the ejecta had consisted entirely of basic-andesite which had poured out without any explosive accompaniments of a major sort. Between the last of these flows and the

Katmai volcano before the eruption



This map shows that there could have been no crater lake before the eruption. The site of the present crater (cf. map on page 45) was occupied by three peaks whose position and altitude were determined with precision by the United States Coast and Geodetic Survey, from whose Chart N⁰. 8555 the figure is traced.

recent outburst had intervened a pause probably many centuries in duration and when activity was resumed it differed materially from what had preceded. The Eruption of 1912 consisted entirely of fragmental products rather than molten lava. First came the great outpour of ash and pumice which is the subject of this note. Then Mt. Katmai blew up in a series of extremely violent explosions which left behind the present gigantic crater in place of the former mountain summit. The total quantity of rock that disappeared from

the top of Katmai during the eruption is estimated at $11{,}000 \times 10^6$ cubic yards (8400×10^6 cubic meters).

Associated with the change in the character of the activity was an equally great change in the composition of the magma concerned. The old lavas are dark-colored basic-andesites with a silica content of about 60 per cent.

But the new magma is a white, acid rhyolite with 75 per cent of silica.

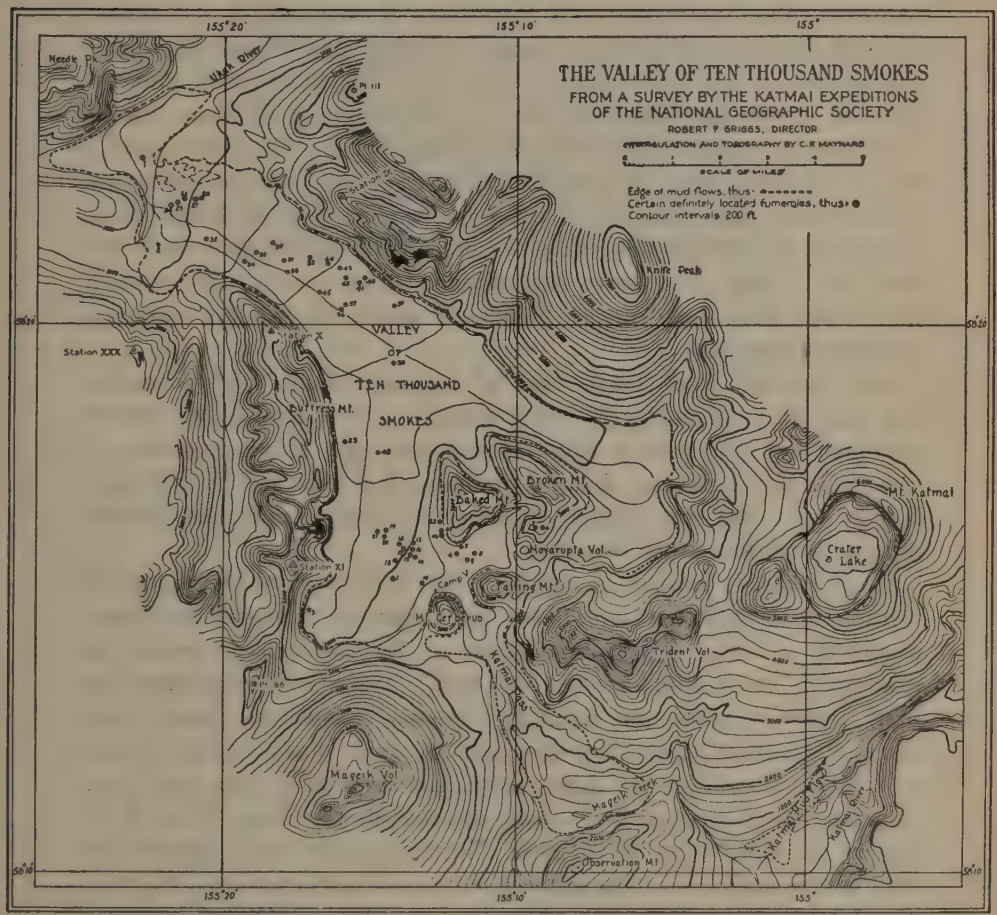
This change in composition of the magma, while without any particular bearing on the point at issue here, is of great significance in interpreting other aspects of the eruption, for it enables us to gain considerable insight into the processes operation before and during the explosions.

A second line of proof that the Incandescent Sand Flow could not have been of the type supposed by Dr. ESCHER is that the slopes of Katmai show no evidence of such a flow having passed over them. As Dr. ESCHER rightly asserts, a lahar erodes in the upper steep portion of its course. Erosion would have been particularly marked if such a flow had passed down the slopes of Katmai, since they were covered with ice, which would have melted away with great rapidity before a hot lahar. Yet the slopes down which Dr. ESCHER assumes the lahar to have coursed are still clothed by the glaciers which originally covered them. To be sure, the heads of these glaciers were blown away in the explosions of the summit of the mountain and their toes were melted back by the flow of incandescent sand across them from Novarupta down the Valley. But these accidents to the extremities only serve to emphasize the undisturbed condition of the middle slopes down which the hypothetical lahar is supposed to have run.

Instead of having flowed down the slopes of Katmai, the mass clearly moved transversely across the base of the volcano. The high sand mark, i.e. the edge of the flow, slopes steadily from south to north across the foot of Katmai. Its altitude at the south edge of the glaciers is several hundred feet greater than at the north edge, thus indicating that it flowed north along the foot of Katmai rather than westward from its heights.

A third circumstance which makes it impossible to assign the origin of the flow to Katmai volcano is the distribution of its material. A more detailed contour map then that published with Dr. ESCHER's argument (see page 45) makes it clear that the greater part of any fluid poured down the western slopes of Katmai would pass through the East arm of the Valley of Ten Thousand Smokes between Knief

Peak and Broken Mountain. A small portion might pass over the divide at Novarupta and run down between Falling Mountain and Baked Mountain. But as a matter of fact the quantity of flow material



Mt. Katmai and the Valley of Ten Thousand Smokes since the eruption. Compare Mt. Katmai with the map on page 43. The contours show that it would be impossible for a liquid flowing under gravity from top of Katmai volcano to reach the head of Mageik Creek via Katmai Pass.

in the Valley leading away from the base of Katmai appears markedly less than that in the main arm of the Valley of Ten Thousand Smokes ten kilometers across the mountains from Katmai. No liquid starting from the summit of Katmai and seeking its level under gravity could possibly reach the summit of Katmai Pass.

It is believed that the map on this page demonstrates this point

sufficiently. But it may be added that the relatively small scale map with contours no closer than 200 feet (60 meters) is much less convincing than an examination of the ground itself. I venture to assert that no one who had made field observations would have suggested the possibility of a flow from Katmai taking the course outlined by Dr. ESCHER. The arrows on his map would make out that a part of the flow turned out of the direct course and climbed the 150 meter slope between Falling Mountain and Trident, instead of continuing in a straight line down the Valley. Not only gravity but also inertia acting as centrifugal force, would have opposed any such course. The presence of the flow in the saddle of Katmai Pass and down the slopes on both sides constitutes inescapable proof that part of it originated near the divide. A good-sized crater which may have been one of the points of origin lies in fact near the summit of the pass.

Any one of these three lines of evidence alone would negative the possibility of our flow being a lahar of the Klut type. Taken together they put such a hypothesis entirely out of the question.

But, if the evidence definitely shows that our flow is not analagous with the hot lahars of Klut, the determination of its real nature is quite another question.

In our earlier studies, recognizing the evident resemblance of the terrane to an ordinary mud flow, we sought to interpret it without assigning a very high temperature to its material — hence the descriptive name applied, "hot mud flow". It was recognized from the first, however, that no ordinary aqueous suspension could ever convert a whole forest into charcoal. Further study made it more and more clear that the mass must originally have been very hot. Charred wood occurs only near the foot of the flow, fifteen kilometers or more from Novarupts. Throughout the main part of the Valley the vegetation was entirely consumed and its ashes dissipated. The rock of a whole mountain, named "Baked Mountain", was changed from gray-green to brick red — as though subjected to a high temperature for a prolonged period.

The stiffened tuff left behind after the sand flow had come to rest differs materially in several respects from the deposits of Klut. In the first place it was much more viscous while in action. The average thickness of the Klut lahar is estimated as only 50 centimeters. The pictures of destruction in Blitar all show a relatively thin veneer of volcanic debris covering the ground. This terminal portion moreover was not very hot as is evidenced by numerous plants with unwithered leaves standing close to the volcanic debris,

e.g. a patch of rank herbage beside the railway station at Blitar. (See this pag.)

In our flow, on the other hand, the average thickness is fifty

Photo from HELMIG & Company.

Volcanic debris from the Lahar of Klut at Blitar about 5 km. above the termimus of the flow. The unburned buildings and unwithered herbage show that the lahar could not have been very hot at this point.

times as great, indicating an entirely different sort of fluid. It is doubtful indeed if the *minimum* thickness of our flow was as low as the average thickness at Klut. Few, if any of the deposits lift on the ground are less than a meter thick. Clear out to the very tip it retained an excessively high temperature. For a considerable distance beyond the present end of the flow material one finds stumps of bushes burned off by the heated material that once covered them but has been eroded away. Outside the limits of the flow itself moreover all trees were killed for some distance and grass fires were started well down toward the tip. See pages 48 and 49.

The deposits left behind, while different from the lahar of Klut, resemble closely those of the "incandescent avalanches" of Pelée and La Soufrière as described by a number of observers, e.g. ANDERSON and FLETT [1]).

This similarity together with the increasing evidence of a high temperature brought out by further study has convinced us as detailed by FENNER [2]) that the tuff filling the Valley of Ten Thousend Smokes originated as an outpour of red-hot material very much like the incandescent avalanches that rolled down the slopes of Pelée and La Soufrière in 1902.

The differences between these and the hot sand flow with which we are dealing appear in fact to be due to differences in the cir-

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[1]) Phil. Trans. Royal Society, A vol. 200; p. 492 et seq. 506 et seq.

[2]) O. p. cit. p. 577.

cumstances of extrusion rather than in the character of the ejecta. Whereas the incandescent avalanches of the West Indian volcanoes issued from old vents of the central type, observations such as have been detailed in the case of Katmai exclude as possible source all of the five old volcanoes adjacent to the Valley of Ten Thousand Smokes.

A section of the sand flow close to the terminus.

Photo by L. G. FOLSOM.

The tree, about 30 cm. in diameter, was entirely reduced to charcoal. The material was much less fluid than the lahar of Klut, for it did not run out into a thin sheet as there, but remained relatively massive close to the extremity. (The sand is covered by stratified ash from Katmai and by outwash of the stream which later cut the section).

The configuration and practically continuous course of the high sand mark entirely around the Valley basin seem to leave no escape

The edge of the incandescent sand flow of the Valley of Ten Thousand Smokes.

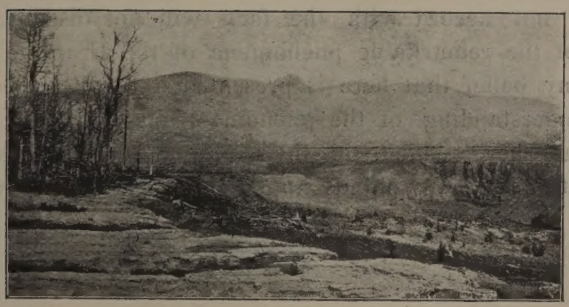

Photo by P. H. HAGELBARGER.

The picture was taken about the same distance, circa 5 km. above the terminus, as the one of Klut. Contrast the total destruction here with the uninjured trees at Blitar. On the original surface where revealed by erosion may be seen the stumps of trees burned off just above the ground.

from the conclusion that the material originated within the confines of the Valley itself, that the vents from which it issued were located within the limits of the high sand mark. Since vents in this situation would be choked by their own products unless vigorously explosive [1]) we need not be surprised if the points of issue are not certainly identifiable.

The distribution of the flow, sloping as it does both ways across two divides, shows that it could not have come from any single vent. A number of considerations suggest that many vents, rather than a few, were probably concerned. The character and distribution of the present fumaroles in the Valley, together with some other circumstances, likewise make it appear more probable that the orifices were fundamentally fissures, not centralized vents on the model of the ordinary volcano.

The nature of the vents from which the incandescent material

[1]) Since the type of material composing the tuff is strictly confined to the Valley basin, not a particle of it being found on the adjacent mountain slopes, it is clear that the magma must have issued comparatively quietly, albeit the material is now thoroughly fragmented, indicating a degree of inflation comparable with the magma of Katmai which exploded with great violence.

issued may, however, remain largely a matter of opinion, but their location within the Valley is, it is believed, definitely established.

In conclusion, may I express my appreciation of the helpful spirit in which Dr. ESCHER has attempted to assist in the solution of what is admittedly a very perplexing question? I shall hope, moreover, that the necessity which I have been under of showing that his thesis does not accord with the facts will not discourage further discussion of the remarkable phenomena of the Eruption of Katmai. For it is my belief that here is presented a unique opportunity to gain an understanding of the phenomena of volcanism; that there are problems here which, in their ultimate solution, will require the coöperation of many minds approaching them from many different angles.

ERRATUM.

In Prof. PEKELHARING's communication: *"On the Movement of Pepsine, a. s. o."* (Proceedings Vol. XXIV, p. 269) to read p. 272, 2nd line from the top **1 mgr.** instead of 0,1 mgr.
